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wherein said forming of at least one polish-stop layer comprises forming a pair of polish-stop layers on an upper surface of said material layer such that a portion of the material layer and the copper extends between and above the pair of polish-stop layers.

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53. (Amended) The method of Claim 39 wherein said polishing comprises polishing the material layer and the copper in a slurry comprising an abrasive and phosphoric acid ( $H_3PO_4$ ).

### REMARKS

This Amendment is submitted in response to the Office Action mailed September 24, 2002, wherein FIG. 18 was objected to for containing reference signs not mentioned in the description, claim 39 was objected to for an informality, claims 36-38 were rejected under 35 U.S.C. §112, ¶1, claims 22-28 and 53 were rejected under 35 U.S.C. §112, ¶2, and claims 22-44 and 47-54 were rejected under 35 U.S.C. §103(a) as being unpatentable over Joshi et al. (U.S. Patent No. 5,731,245) in view of Roberts (U.S. Patent No. 4,959,113). In addition, the Examiner has indicated that claims 45-46 would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. In response, claims 22, 29, 36, 39, 45, 46, and 53 have been amended. Claims 1-21 were previously canceled without prejudice. **Claims 22-54 are pending in the application.**

Attached hereto is a marked-up page version of the changes made to claims 22, 29, 36, 39, 45, 46, and 53 by the current amendment. The attached page is captioned "**VERSION WITH MARKINGS TO SHOW CHANGES**". Applicants respectfully submit that no new matter has been entered by the amendments to claims 22, 29, 36, 39, 45, 46, or 53.

For the reasons set forth below, Applicants respectfully submit that all remaining claims in this application are patentably distinct over the prior art of record. Reconsideration and allowance of all pending claims in the application are respectfully solicited.

#### **Objection to FIG. 18**

Figure 18 was objected to as failing to comply with 37 C.F.R. §1.84(p)(5) because it includes the reference sign "PI" that is not identified in the specification. In response, the specification has been amended to reflect that the reference sign "PI" refers to polyimide.

**Objection to Claim 39**

Claim 39 was objected to for the informality of the word “contracting.” In response, Claim 39 has been amended as suggested by the Examiner.

**Rejections under 35 U.S.C. §112, ¶1**

Claims 36-38 have been rejected under §112, ¶1 as containing subject matter not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventors had possession of the claimed invention at the time the application was filed. In response, the claim 36 has been amended to correct a typographical error. This amendment is supported by FIG. 18 and the corresponding discussion in the specification, which shows the addition of phosphoric acid decreases the W removal rate while not decreasing the removal rate of PI or Cu. Applicants therefore respectfully request that the Examiner withdraw the rejection under §112, ¶1 of independent Claim 36 and dependent Claims 37 and 38.

**Rejections under 35 U.S.C. §112, ¶2**

Claims 22-28 and 53 have been rejected under §112, ¶2 as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. In response, Applicants have amended claims 22 and 53. Support for the changes is found in the specification. Applicants respectfully requested that the Examiner withdraw the rejection of Claim 53 under §112, ¶2.

**Reasons for Allowability for Claims 22-35, 39-44 and 47-54**

Claims 22-44 and 47-54 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Joshi et al. (U.S. Patent No. 5,731,245) in view of Roberts (U.S. Patent No. 4,959,113). Regarding claims 22-35, 39-44 and 47-54, independent claims 22, 29, and 39 have been amended to more clearly recite an aspect of the invention previously claimed, and Applicants respectfully submit that independent claims 22, 29, and 39 and dependent claims 23-28, 30-35, 39-44 and 47-54 are non-obvious and allowable over the Joshi et al, Roberts or any combination thereof. Action to that end is respectfully solicited.

Joshi et al. teaches polishing a layered structure of a hard cap over a copper layer over a dielectric layer with a solution not taught to contain phosphoric acid. In particular, the structure

of Joshi et al. is a planar structure having lines or vias (col. 3, lines 3-6) as shown in FIGS. 1-3. Roberts teaches methods and compositions for rapidly polishing metal surfaces to produce a high quality, mirror-like surface (col. 1, lines 7-11 and col. 2, lines 4-6). The metal surface is the only surface being polished or planarized and does not act as a polish-stop for other layers. The addition of phosphoric acid, as disclosed, “enhances performance of the polishing composition and method.” col. 3, line 67 – col. 4, line 1). The enhanced performance referred to in Roberts refers to the ability to form a smooth surface, not to act as a better polish top layer, and there is no teaching or suggestion in Roberts either to use the abrasive compounds for allowing the use of a metal surface as a polish-stop, or to use the abrasive compounds to polish a dielectric layer, as is contained in the present invention’s material layer.

Claims 22, 29, and 39 describe a protruding structure comprising a material layer and copper is etched before a tungsten polish stop layer. Claims 22, 29, and 39 have been amended to clarify this aspect. The amendments are supported by FIGS. 3-5 and 11, for example, and in the corresponding description of the two full paragraphs on page 7 of the specification.

Applicants respectfully submit that the amendments to Claim 22, 29, and 39 do not enter new matter.

Applicants respectfully submit that neither Joshi et al. nor Roberts teaches or suggests amended claims 22, 29, and 39, since they fail to teach or suggest the polishing of protruding structures. Moreover, Applicants respectfully submit that it would not be obvious to modify either Joshi et al. or Roberts to meet the limitations of Claim 22, 29, and 39, since the central inventive purpose of the Joshi et al. is to produce smoothed lines or vias, and the purpose of Roberts is to produce a mirror-like finish on a flat metal surface. There would thus be no motivation to modify the references to obtain a method to polish a structure having protruding material layers and copper.

For the above reasons, Applicants respectfully submit that independent claims 22, 29, and 39 and dependent claims 23-28, 30-35, 39-44 and 47-54 are non-obvious and allowable over the Joshi et al., Roberts, or any combination thereof. Action to that end is respectfully solicited.

#### **Reasons for Allowability for Claims 36-38**

Regarding the claims 36-38, independent claim 36 recites adding components to a polishing slurry to affect the relative polishing rates of the polished layers. As noted above, independent claim 36 had been amended in response to the rejection under §112, ¶1 to reciting

that the method decreases the rate at which tungsten material is removed by a polishing slurry in a polishing process while not decreasing the rate at which copper material is removed by adding phosphoric acid to the polishing slurry. Applicants respectfully submit that independent claim 36 and dependent claims 37-38, as amended, are non-obvious and allowable over any combination of the cited references.

The Examiner has stated that Joshi et al. teaches a polish-stop layer that is more resistant to the polishing slurry. While this is true, there is no teaching in Joshi et al. regarding adding phosphoric acid to affect the each rate. In addition, Roberts is directed to obtaining a smooth metal finish, and not to a polish-stop layer. The references also neither teach nor suggest modifications of the references to obtain the invention so claimed.

For the above reasons, Applicants respectfully submit that independent claim 36 or dependent claims 37-38 are non-obvious and allowable over the Joshi et al., Roberts, or any combination thereof. Action to that end is respectfully solicited.

#### **Allowable Claims**

The Examiner has indicated that claims 45 and 46 would be allowable if rewritten to include all of the limitations of the base claim and any intervening claims. As noted above, claims 45 and 46 have been canceled with this Amendment, and now include all of the limitations of the base claim and any intervening claim. Claims 45 and 46 are thus believed to be in condition for allowance.

If a telephone conference would expedite prosecution of this application, the Examiner is invited to telephone the undersigned at (415) 409-2900.

Respectfully submitted,



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**VERSION WITH MARKINGS TO SHOW CHANGES**

Additions are shown in **bold-faced** type. Deletions are **bold-faced** and enclosed in brackets [ ].

**In the Specification:**

The paragraph beginning on Page 14, line 9 has been amended as follows:

The removal rate of tungsten was found to be lower in acidic slurries than in alkaline slurries, and this is believed to be due to the formation of an oxide layer over the tungsten in acidic (low pH) slurries. This oxide layer retards the chemical-mechanical polishing of tungsten. Therefore, it is desirable to polish the samples in acidic slurries so that a thin tungsten layer can hold up longer and serve more effectively as a polish-stop layer. The chemistry of commercial slurries was modified by adding various acids to adjust the pH to be within the acidic range ( $\text{pH} < 7.0$ ), and the effects of these acids on polish selectivity were experimentally studied by examining the chemical etching rate of copper, polyimide, and tungsten individually. Copper was etched by nitric acid roughly in proportion to the nitric acid concentration, while neither tungsten **[or]** **nor** polyimide substantially dissolved in nitric acid. When nitric acid was added to the originally alkaline silica slurry, undesirable dishing in copper was observed as a result of fast chemical etch of copper during polishing. Since acidic slurries are desirable for achieving a slow removal of tungsten, an acid to which copper is inert is preferably added to the slurry. The inventors have discovered that phosphoric acid ( $\text{H}_3\text{PO}_4$ ) has no significant erosion to copper (Cu), tungsten (W) or polyimide (**PI**) at room temperature. The removal rates using silica slurry blended with nitric acid and phosphoric acid, respectively, are presented below in TABLE II in the units of Angstroms per minute ( $\text{\AA}/\text{min}$ ):

**In the Claims:**

Claims 22, 29, 36, 39, 45, 46, and 53 have been amended as follows:

22. (Twice Amended) A chemical mechanical polishing method of planarizing a **protruding** structure comprising a material layer and copper (Cu), said **protruding** structure being formed on a surface of a substrate, said method comprising the steps of:

- (a) forming a polish-stop layer comprising tungsten (W) which is positioned along at least one side of **[the] said protruding** structure;
- (b) polishing initially the material layer **of said protruding structure** in a slurry comprising an abrasive and phosphoric acid ( $H_3PO_4$ ); and **thereafter**
- (c) polishing **[subsequently and simultaneously]** the material layer and the copper in the slurry **of said protruding structure** until contacting the polish-stop layer.

29. (Amended) A method of polishing a **protruding** structure comprising a material layer and copper (Cu), said structure being formed on a surface of a substrate, said method comprising:

- (a) forming a polish-stop layer comprising tungsten (W) which is positioned along at least one side of **[the] said protruding** structure; and
- (b) polishing simultaneously the material layer and the copper **of said protruding structure**.

36. (Amended) A method of decreasing the rate at which tungsten material is removed by a polishing slurry in a polishing process while not **[increasing] decreasing** the rate at which copper material is removed, said method comprising adding phosphoric acid to the polishing slurry.

39. (Amended) A chemical mechanical polishing method of planarizing a structure comprising:

- providing a substrate supporting a material layer including **protrusions comprising** at least partially embedded copper (Cu);
- forming at least one polish-stop layer on the material layer; and
- polishing the material layer and the copper before **[contracting] contacting** the polish-stop layer.

45. (Amended) **[The method of Claim 39] A chemical mechanical polishing method of planarizing a structure comprising:**

**providing a substrate supporting a material layer including protrusions comprising at least partially embedded copper (Cu);  
forming at least one polish-stop layer on the material layer; and  
polishing the material layer and the copper before contracting the polish-stop layer,**

wherein said forming of at least one polish-stop layer comprises forming said at least one polish-stop layer on an upper surface of said material layer such that a portion of the material layer and the copper extends above the polish stop layer.

46. (Amended) **[The method of Claim 39] A chemical mechanical polishing method of planarizing a structure comprising:**

**providing a substrate supporting a material layer including protrusions comprising at least partially embedded copper (Cu);  
forming at least one polish-stop layer on the material layer; and  
polishing the material layer and the copper before contracting the polish-stop layer,**

wherein said forming of at least one polish-stop layer comprises forming a pair of polish-stop layers on an upper surface of said material layer such that a portion of the material layer and the copper extends between and above the pair of polish-stop layers.

53. (Amended) The method of Claim 39 wherein said polishing comprises polishing the material layer and the copper in a slurry **[consisting of] comprising** an abrasive and phosphoric acid (H<sub>3</sub>PO<sub>4</sub>).